AD-A145 494 DESIGN CONSTRUCTION DEMONSTRATION AND DELIVERY OF AN AUTOMATED NARROW GAP WELDING SYSTEM(U) CRC AUTOMATIC WELDING CO HOUSTON TX 05 NOV 81 CRC-NAV-A/W-1 1/1

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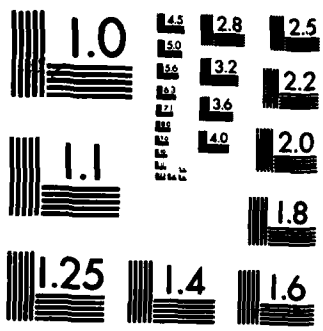


CRC REPORT NO. NAV A/W 1

PHASE I REPORT

ON

# DESIGN, CONSTRUCTION, DEMONSTRATION AND DELIVERY OF AN AUTOMATED NARROW GAP WELDING SYSTEM

CONTRACT NO. N00600-81-C-E923

TO

DAVID TAYLOR NAVAL RESEARCH AND DEVELOPMENT CENTER
DEPARTMENT OF THE NAVY

FROM

CRC AUTOMATIC WELDING
NOVEMBER 5, 1981



## INTRODUCTION

The objective of this program is to design, construct, demonstrate, and deliver an automated, Narrow Gap welding system capable of welding high strength steel plates under shipyard production conditions in the construction of aircraft carriers. The unique feature of the automated Narrow Gap welding process, is the narrow (1/4 - 3/8 - inch), square-butt joint design. This narrow joint greatly reduces the volume of weld metal required for thick (2-4 inch) plates compared to the conventional, beveled joint design in current practice and represents the potential of providing reduced time and cost fabrication procedures. The weld metal is deposited with a modified, gas, metal-arc welding (GMAW process) resulting in very high joint finishing rates, excellent weld mechanical properties, and less distortion from welding.







Enclosure (1)

The program will be conducted in five phases:

(1) Definition of Requirements

(2) Design of Welder Package

(3) Equipment Construction

(4) Qualification of Process and Equipment

(5) Shipyard Demonstration.

This report summarizes the results of Phase I.

## OBJECTIVE OF PHASE I - DEFINITION OF REQUIREMENTS

Phase I was devoted to a thorough review of the requirements that must be met by a shipyard production Automated Narrow Gap Welding System (ANGWS). The requirements were determined by (1) a meeting with DTNSRDC personnel on 24 & 25 Aug. 1981 at CRC facilities in Houston, Texas to discuss operational requirements. (2) a visit on 10 Sep. 1981 to the David Taylor Naval Ship Research and Development Center in Annapolis, MD to witness the existing Prototype ANGWS in actual operation, and further discuss operational and personnel requirements (3) a visit on 25 Sept. 1981 to the Newport News Shipbuilding Co. in Newport News, VA. in order to obtain operational and personnel requirements from the welding engineering department to ensure that the design of the ANGWS would be suitable for shipyard production use, and observe the current method of welding heavy plating at the shipyard fabrication facilities, (4) a review of the reports prepared by the NNS Co. (Requirements for ANGWE & Additional requirements for ANGWE techniques) pertaining to Narrow Gap Welding, (5) a review of the DTNSRDC report (Automated Narrow Gap Welding Development) pertaining to the Prototype narrow gap welder, and (6) a review of industry published literature, and technical reports to evaluate the latest development stage of the ANGW process, and any new equipment being utilized or under consideration. Phase I was reviewed by Newport News Representatives on November 6 and was found acceptable.

As a result of the comprehensive investigation conducted above the Definition of Requirements for a ANGW system successfully capable of welding heavy plating in a shipyard environment are summarized below:

## EQUIPMENT REQUIREMENTS

The Automated Narrow Gap welding system will consist of: (1) welding head and guidance system, (2) travel tractor that supports the welding head and wire spool, (3) the welding controls, and (4) the welding power supply.

### Welding Head And Guidance System

The welding head and guidance system will automatically track the weld seam, automatically vary the oscillation width as necessary, and automatically maintain the desired contact tube-to-work distance (CTWD). This will be done by sensing the slight change in the arc voltage-amperage relationship as the electrode traverses the weld joint and approaches the sidewall. On command from the sensing system, the electrode will reverse the direction of oscillation. The usable range of welding parameters will be stored in a microprocessor located remotely by the welding power supply. The microprocessor will vary wire-feed speed, weld travel speed, oscillation width and frequency, and arc voltage as required to maintain a constant heat input ( $\frac{\text{voltage x amperage}}{\text{travel speed}}$ ) and a constant weld height. The commands from the microprocessor to the welding head will be transmitted through a fiber optics cable. The operator controls on the welding head will include arc start, emergency stop, wire inch.

Other features of the welding head/guidance system will be as follows:

1. The welding head/guidance system will be rugged and capable of supporting the wire drive, wire spool, and torch assembly.

2. The wire drive will provide a wire feed speed range of 30- to 940 ipm with a wire diameter range of 0.030-0.062 inch.

3. The vertical torch lift assembly will have a 6-inch total movement. The automatic CTWD control will be operable over this same range.

4. Arc voltage will be sensed at the welding head and used to control remotely the welding power supply.

5. The lateral, cross-seam control will provide 3-inches of lateral movement for oscillation and seam tracking.

6. The guidance system will be capable of tracking the weld joint through the range of cross-seam adjustments less the oscillation width.

7. The welding head/carriage assembly will accommodate a standard 30-pound filler wire spool.

8. The contact tube assembly designed and built by DTNSRDC will be considered. However, the optimum design selected will incorporate the most current technology available to minimize maintenance problems. It will have sufficient cooling capacity for the desired welding voltage/current. The contact tube assembly will be capable of full horizontal and vertical skew.

9. The shielding gas assembly designed and built by DTNSRDC will be modified to incorporate the most current technology to ensure maximum weld quality.

10. The microprocessor will maintain full control over the welding parameters during normal welding operations.

11. Digital arc voltage, amperage meters, wirefeed speed, and travel speed will be provided on the welding carriage. Each monitoring parameter will be switch selectable.

12. A simple, periscope-type arc-viewing system will be provided.

13. The torch assembly must have the capability of welding on metal backing bars or ceramic tape.

## Travel Tractor

The travel tractor will support the welding head, wire spool, and controls. The requirements of the tractor are as follows:

1. The total weight of the tractor, welding head and wire-spool will not exceed 200 pounds.
2. A lifting eye and the balanced lift point will be provided to accommodate moving the equipment from one location to another.
3. The travel carriage speed range will be 1-to 30 ipm.
4. Motor speed regulation will be provided to $\pm$ 0.1 percent of set speed.
5. The tractor will ride on a standard, submerged-arc track to permit elevation of the track above the preheat cables and to utilize the track currently used for heavy section shipyard plate fabrication.
6. Provision will be made to disengage the tractor drive wheels for freewheeling along the track.

## Welding Controls

The welding controls will be remote to the welder/carriage assembly. It will be state-of-the-art, solid-state electronic control. Other features will be:

1. The design will incorporate self-diagnostic circuits to assist in trouble shooting and maintenance.
2. The control will be modularized incorporating printed-circuit boards which can be easily replaced and tested.
3. An RCA 1802, 8 bit microprocessor will be used for welding parameter control and seam tracking routines. All communications between the welding head and the control system will be through fiber optic cables. This will provide maximum isolation and noise rejection characteristics.
4. The welding control will provide all essential weld start up and shutdown sequences.

5. The controls will be housed in a weather and dustproof enclosure.

6. Standard, off-the-shelf components will be used where possible.

7. The welding control as well as the welding power supply will have 200 feet of interconnecting cables to the welding heads. The interconnecting cables will be able to be disconnected from each component. All control cables will be so designed as to provide easy field repair and or replacement.

8. The control will provide dynamic braking of the wire-drive motor to prevent wire over-run, adjustable anti-stick time, slow wire inch speed, pre-flow and post-flow gas, crater fill and wire stop.

9. Digital welding amperage, weld voltage, travel speed and wirefeed speed meters will be provided at the welding control enclosure.

## Welding Power Supply

The final choice of welding power supply will be based on the results of Phase II evaluations of commercial supplies. However, the following guidelines will be used in this selection:

1. The power supply will be a solid-state, rectifier type of at least 450 ampere, 100-percent duty cycle rating.

2. Pulsing will not be required.

3. It must be voltage-compensated with a 440-volt, three-phase input.

4. Must be a domestic power supply.

## OPERATIONAL REQUIREMENTS

1. The system must be capable of sustained operation with routine maintenance checks.

2. The system must be capable of continuous operation on 2- to 4-inch thick, HY-100 steel plate preheated to 200-300 F.

3. The system must be capable of welding up to 40-foot long weld joints to within 6-inches of bulkheads transverse to the weld and parallel to bulkheads located 6-inches from one side of the weld.

4. The system must be able to produce acceptable welds in joint openings of 3/8-inch ± 1/8-inch wide with bevel angle of the joint 0-to 3 degrees inclusive. Also, the system must tolerate plate alignment or high-low of up to 1/8-inch and plate unfairness of up to ± 3/8 inch in 48-inches.

## ENVIRONMENTAL REQUIREMENTS

The shipyard is a hostile environment. The system must be able to perform under the following environmental conditions:

1. Ambient temperature range of -10F to + 110F.
2. Humidity up to 99 percent.
3. Normal dirt and dust from grinding, arc-air gouging and sandblasting operations.
4. Deck surfaces with localized partitions or screens for effective wind breaks.
5. Typical shipyard electrical noise interference and vibration.

## PERSONNEL REQUIREMENTS

The system shall be designed for operation by qualified shipyard mechanized welding process operators, such as submerged arc welders. No other specialized welding experience shall be necessary. Operating and maintenance manuals shall be provided to accommodate the skills of the qualified shipyard operator.

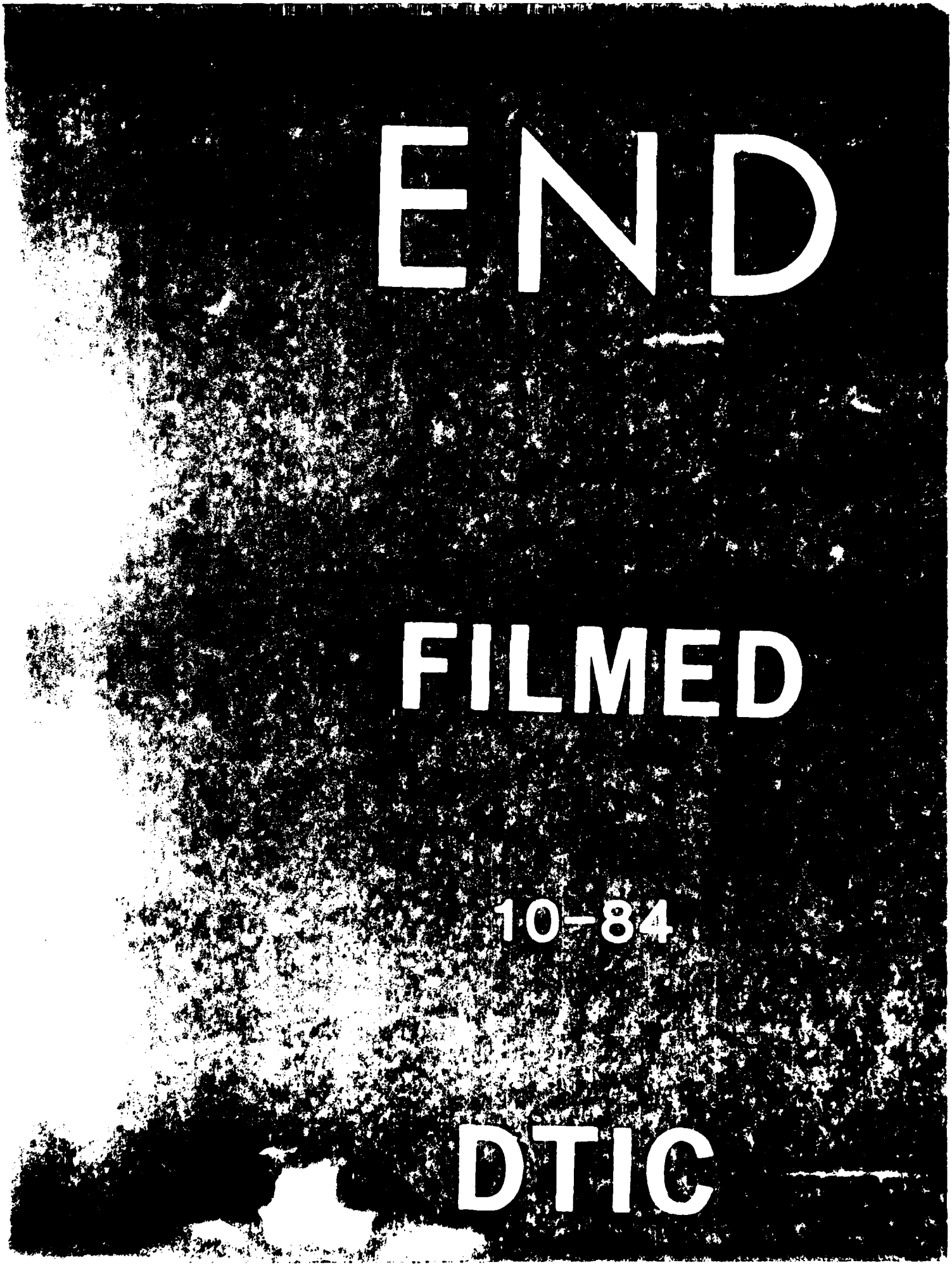
## SUMMARY

The Automated Narrow Gap system to be designed in phase II of this program must meet the foregoing requirements. The design philosophy that will be used is as follows:

1. Keep the design and manufacture as simple as possible consistent with operational requirements.
2. Design and build in high equipment reliability, portability and ruggedness.

3. Make the equipment simple to operate with a high degree of reproducibility in a typical shipyard environment.

4. Make the equipment simple to maintain utilizing available shipyard skills.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